METHOD AND SYSTEM FOR MISSION MODULE SWAPPING IN A VESSEL

CLAIM OF PRIORITY

[1] This application claims priority from U.S. Provisional Application Serial No. 60/426,070 filed on November 12, 2002, which is incorporated by reference.

CROSS REFERENCE TO RELATED APPLICATIONS

[2] This application is related to U.S. Patent App. Serial Nos. ____ entitled **MISSION MODULE SHIP DESIGN** (Attorney Docket No. 1934-7-3), and ____ entitled **VESSEL WITH A MULTI-MODE HULL** (Attorney Docket No. 1934-9-3), which have a common filing date and owner, and which are incorporated by reference.

BACKGROUND OF THE INVENTION

[3] Modern naval ships are typically designed to perform multiple types of missions, and are, therefore, referred to as "multi-mission" ships. For example, suppose a ship is designed for anti-submarine warfare, littoral warfare, and anti-mine warfare. Such a ship may include a deck that has a respective command/control station for each type of mission, *i.e.*, a station for anti-submarine warfare, a station for littoral warfare, and a station for anti-mine warfare. The ship may also have a hull that, although not ideal for any particular type of mission, is at least compatible with all of the mission types for which the ship is designed.

[4] One problem with such a multi-mission-type ship is that it is often larger than it needs to be for a single type of mission. For example, if a deck of the ship has a

respective command/control station for each type of mission, then the deck, and most likely the ship, is bigger than it would be if it included only a single station for a single type of mission. Mulit-mission ships are, therefore, high-value capital assets, typically carry a large crew to support the various missions, and are generally operated only in regions where a high degree of protection is supplied by other friendly ships.

[5] Another problem is that multi-mission-type ships are typically inefficient. For example, if the ship is designed to perform three types of mission and includes a respective command/control station for each mission type, then two of the three stations are typically unused when the ship is on a mission.

[6] Furthermore, the hull of such a multi-mission ship is typically not ideal for any of the mission types for which the ship is designed. That is, if the hull is ideal for one type of mission, it may be incompatible with another type of mission. Therefore, when designing a hull that is compatible with multiple types of missions, a designer must often design the hull as a compromise across all missions.

SUMMARY OF THE INVENTION

[7] An embodiment of the invention is directed to a method for maneuvering a vessel near a mission module, capturing the module with the vessel, and then coupling the mission module to the vessel.

[8] By interchanging mission modules, a crew can quickly and easily provide the ship with different mission capabilities. More specifically, by designing a hull structure with a bay for different types of mission modules, a first module designed to provide systems and facilities for a first type of mission can be removed and a second mission module designed to provide systems and facilities for a second type of mission can be installed. Because the interfaces between each mission module and the hull structure and/or the

ship's control systems are typically compatible for most mission modules, retrofitting a ship for a different mission is achieved quickly and easily.

[9] Furthermore, because the mission modules are easily interchanged, a ship may be retrofitted while deployed. That is, a ship may jettison a first mission module and then acquire a new mission module without the requirement of leaving the operating theater and transiting to friendly port or to a dry dock.

BRIEF DESCRIPTION OF THE DRAWINGS

[10] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings.

[11] **FIG. 1** is an isometric view of a multi-mission ship and an associated mission module according to an embodiment of the invention.

[12] **FIG. 2** is a cutaway plan view of a multi-mission-type ship with a mission module engaged according to an embodiment of the invention.

[13] **FIGS. 3A – 3D** illustrate a procedure for changing mission modules in the ship of **FIG. 1** according to an embodiment of the invention.

[14] **FIG. 4** illustrates an alternative procedure for changing mission modules in the ship of **FIG. 1** according to an embodiment of the invention.

[15] **FIGS. 5A – 5D** are end views of a ship having a multi-mode hull according to an embodiment of the invention.

DETAILED DESCRIPTION

[16] **FIG. 1** is an isometric view diagram of a multi-mission ship ***100*** and an associated mission module ***105*** according to an embodiment of the invention. The ship ***100*** may be a monohull, a multihull (such as a catamaran, Trimaran, Pentamaran, etc.), a small-waterplane-area twin hull (SWATH), a multi-mode hull such as discussed gelow in conjunction with **FIGS. 5A – 5D**, or other type of hullform. The ship ***100*** includes a hull structure or frame ***115*** that is designed to accept one or more mission modules ***105*** (only one shown in **FIG. 1**). The frame ***115*** includes two lower hull portions ***112a*** and ***112b*** and associated interconnecting structures (called struts hereinafter) that extend down from a main body ***113***, (one strut and lower hull ***112a*** extending down from the port side and one strut and lower hull ***112b*** extending down from the starboard side) such that a receptacle or bay ***110*** is enclosed by the struts and lower hulls ***112a*** and ***112b*** and the main body ***113***. The bay ***110*** creates a cavity such that water is free to flow in and out of the bay area as the hull portions ***112a*** and ***112b*** are only coupled to the main body ***113*** which stays above the surface of the water because of the buoyancy of the struts and lower hulls ***112a*** and ***112b***. As such, a small watercraft or other floating objects may traverse into the bay ***110***, below the main body ***113***, between the struts ***112a*** and ***112b***, and even out the back side of the ship ***100*** without ever contacting the any portion of the ship ***100***. Similarly, a mission module ***105*** may also pass through the ship ***100*** in this manner, however, a mission module ***105*** is typically engaged (by a lifting mechanism described below) when it is directly under the ship ***100***. In an alternative embodiment, the back side of the ship ***100*** is not open to the water and objects may not pass completely through the bay ***110*** from one side to the other.

[17] Mission modules ***105*** are designed with different capabilities that, when interfaced with the ship ***100***, provide the ship ***100*** with mission-specific functionality for

respective types of missions. That is, a mission module ***105*** is capable of carrying the equipment and supplies necessary to conduct a specified mission. In this aspect, the ship ***100*** is somewhat analogous to a personal computer that includes a mother board (analogous to the frame ***115***) designed to accept one or more plug in cards (analogous to the mission module ***105***) that give the computer a desired functionality. Consequently, the ship ***100*** can be retrofitted for a particular type of mission merely by swapping out one mission module ***105*** for another. As discussed below, by designing a mission module ***105*** for a specific mission, one can quickly retrofit the ship ***100*** while deployed (as opposed to being in a port) such that the ship's retrofit downtime is reduced.

[18] Generally, a mission module ***105*** comprises a watertight exterior and a reinforced interior structure that includes associated propulsion and auxiliary systems such that the mission module ***105*** is sufficiently sea worthy for short distance transits from one ship or dock to the intended host frame.

[19] More specifically, as discussed above, a mission module ***105*** typically includes the equipment and other resources necessary to execute a particular type of mission. For example, the module ***105*** may include, *e.g.,* one or more mission-specific operator/control stations (not shown), a mission-specific computer system, quarters and supplies (not shown) for additional crew needed for the mission, hangers for mission-specific equipment such as a helicopter or unmanned vehicle, and a tank for extra fuel.

[20] The mission module ***105*** may also enhance the non-module, *i.e.,* permanent, resources of the ship ***100*** for compatibility with the type of mission(s) for whichthe module is designed. For example, the ship ***100*** may include a general operator/control

station (not shown), which the computer system of the module ***105*** can configure for the corresponding type of mission via an interface with the ship's computer system. Or, the module ***105*** may carry extra fuel and supplies for a long-range mission.

[21] Still referring to **FIG. 1**, although the module ***105*** is separable from the frame ***115*** of the ship ***100***, when installed in the bay ***110***, the module appears as an integral part of the ship according to an embodiment of the invention. For example, it is contemplated that in a module ***105*** having operator/control stations and/or crew quarters, crew would enter and exit the module in the same manner that they would any other portion of the ship.

[22] Mission-modules ***105*** are contemplated for a number of mission types, including, but not limited to, anti-mine warfare, anti-submarine warfare, littoral operations, search and rescue, stealth delivery of personnel or supplies, a logistics support system such as special equipment transport or medical facilities, and/or a maritime intercept system. Alternatively, the module ***105*** may merely be used to provide the ship 100 with additional fuel, supplies, or cargo space. Furthermore, although described as supporting a single type of mission, the mission module ***105*** may support multiple mission types. In addition, although shown as including a single bay ***110***, the frame ***115*** may include multiple bays ***110*** that can each receive a respective module ***105***.

[23] **FIG. 2** is a cutaway plan view of the multi-mission ship ***100*** with the mission module ***105*** engaged within the bay ***110*** according to an embodiment of the invention.

[24] The systems of the mission module ***105*** are connected to the respective systems of the ship ***100*** via ship-to-module interfaces as discussed below. Specifically, the ship-to-module interfaces include physical connections between the frame ***115*** and the mission module ***105***. For example, as shown in **FIG. 2**, cross-mounting structures ***201***

hold the mission module ***105*** securely within the bay ***110*** while the mission module is engaged therein. A fuel interface ***210*** provides the capability to transfer fuel to and from the mission module ***105***. A water interface ***211*** provides the capability to transfer fresh and/or waste water to and from the mission module ***105***. A computer and electrical interface ***212*** allows the transfer of electricity to and from the mission module ***105***, and allows the mission-module computer system to communicate with the frame ***115*** computer system. Alternatively, if the mission module ***105*** includes no computer system, the interface ***212*** allows the frame ***115*** computer to connect to and control the module. Other ship-to-module interfaces are contemplated, but are not discussed for brevity.

[25] After the mission module ***105*** enters the bay ***110***, crew members mate each ship-to-module interface on the mission module ***105*** with the corresponding interface on the frame ***115***. Alternatively, the mating of the interfaces may be automated. In one implementation, the interfaces are universal for all ships ***100*** and mission modules ***105*** in a fleet so that a crew can install virtually any mission module ***105*** in the bay ***110*** of virtually any ship frame ***115*** using a common installation procedure. Likewise, a crew can remove virtually any mission module ***105*** from any bay ***110*** using a common removal procedure.

[26] Alternate embodiments of the frame ***115*** and module ***105*** are contemplated. For example, although the bay ***110*** is described is being entirely below a deck (topside) of the ship ***100***, the frame ***115*** may have one or more deck openings (not shown) that allow portions of the module ***105*** to be exposed for use. For example, the module ***105*** may include a weapons turret (not shown) or an antenna array (not shown) that protrude through the deck openings. Or, the module ***105*** may include an elevator that can carry planes onto the ship deck via a deck opening.

[27] **FIGS. 3A – 3D** illustrate a procedure by which a crew replaces a first mission module ***105a*** with a second mission module ***105b*** according to an embodiment of the invention. As discussed below, this procedure allows a crew to retrofit the ship ***100*** relatively quickly and while out at sea, and thus eliminates the need for the ship to return to port for retrofitting.

[28] As shown in **FIG. 3A**, the ship ***100*** disengages the first mission module ***105a***. When disengaging the first mission module ***105a***, crew members or other automatic means disconnect each ship-to-module interface (as shown in **FIG. 2**) between the frame ***115*** and the first mission module ***105a***. Then, the crew adjusts the draft (*i.e.*, the depth of the struts ***112a*** and ***112b*** in the water)) of the ship ***100*** to the proper level such that the first mission module ***105a*** is free to float out of the bay ***110***. The ship ***100*** may then begin moving away from the first mission module ***105a*** in the direction indicated by the arrow ***351*** to completely remove the module ***105a*** from the bay ***110***. In an alternate implementation, the ship ***100*** may include a crane or other lifting device (not shown) to remove the module ***105*** from the bay ***110*** and lower the module into the water. For example, the ship ***100*** may include straps (not shown) that engage the bottom of the module ***105a***. The crew can, therefore, lower the module ***105a*** into the water by means of the straps and associated winching system (not shown).

[29] Next, as illustrated in **FIG. 3B,** the ship ***100*** maneuvers away from the first mission module ***105a*** as indicated by the directional arrow ***352.*** After moving far enough away from the first mission module ***105a***, the ship ***100*** then maneuvers into alignment with a second mission module ***105b*** as indicated by directional arrow ***353***. Another ship (not shown) typically transports the second module ***105b*** to the ship ***100*** and recovers the first module ***105a***.

[30] Next, as illustrated in **FIG. 3C,** the ship ***100*** traverses forward and toward the second mission module ***105b*** as indicated by directional arrow ***354***. The crew then aligns the bay ***110*** with the module ***105b***, and sail toward the mission module such that it enters the bay ***110***.

[31] Finally, as illustrated in **FIG. 3D,** the ship ***100*** maneuvers into a final alignment position such that the second mission module ***105b*** can be secured within the bay ***110***. Once the second mission module ***105b*** is fully within the bay ***110***, the crew (or automatic means) of the ship ***100*** may then secure the second mission module within the bay. Next, each ship-to-module interface (**FIG. 2**) between the ship frame ***115*** and the second mission module ***105b*** is connected according to the requirements of the functionality for which the second mission module is designed. Alternatively, where the draft of the ship ***100*** is such that the second mission module ***105b*** cannot float into the bay ***110***, the crew may raise the second mission module out of the water and into the bay with a crane system or other similar lifting system (not shown). For example, the module ***105b*** may be within or more loops formed by one or more straps (not shown) that hang down into the water (beneath the module ***105b***) from the bay ***110***. Then, when the module ***105b*** is in the proper position, the crew can activate a winch or other device (not shown) to reel in the straps, and thus pull the module ***105b*** up into the bay ***110***.

[32] Once the second mission module ***105b*** is engaged within the bay ***110***, the ship ***100*** is ready to begin its new mission. Still referring to **FIGS. 3A – 3D**, in another implementation, the module ***105*** can include a motor or other propelling device such that it can maneuver into the bay ***110***. For example, crew on board the module ***105*** can steer the module into the bay ***110***, or crew on board the ship ***100*** can steer the module via remote control.

[33] **FIG. 4** illustrates a procedure for removing and installing mission modules according to another embodiment of the invention. For brevity, only the installation procedure is described here, it being understood that the removal procedure is merely the installation procedure in reverse.

[34] Referring to **FIG. 4**, the frame ***115*** includes a ramp ***150*** that extends from the bay ***110*** via an opening at either the bow or stern of the ship ***100***. Using a winch assembly or other assembly (not shown), the crew pull the module ***105*** up the ramp ***150*** and into the bay ***110***. The crew may increase the draft of the ship, thus lowering the bay ***110*** opening toward the water, to facilitate the installation of the module ***105***. After the module ***105*** is fully within the bay ***110***, the crew retracts the ramp back into the bay ***110*** (for example, beneath the installed module ***105***). As discussed above, to remove the module ***105***, the crew extends the ramp ***150*** and pushes the module out of the bay ***110***, down the ramp, and into the water.

[35] Once the mission module ***105*** is within the bay ***110***, the crew can secure the module within the bay ***110*** and can interface the various module systems to the frame ***115*** systems as discussed above in conjunction with **FIGS. 1 – 3**.

[36] Referring to **FIGS. 1 – 4**, the modular design of the ship ***100*** provides many advantages in addition to those discussed above. For example, the module ***105*** can be readied in port, and the crew can be trained in port, while the ship ***100*** is executing a mission with another module. Then, the module ***105*** and crew can rendezvous with the ship ***100***, and the modules can be swapped as described above so that that ship is ready for its next mission without coming into port.

[37] And although the ship ***100*** is described as a water-going vessel, the modular concept is applicable to other vehicles. For example, an airplane may have a modular

passenger cabin. Consequently, ground crew can prepare the cabin and load the passengers while the plane is still in the air or is being serviced. When the plane lands, the crew removes one passenger cabin from the plane, and installs another pre-boarded and/or and pre-prepared cabin into the plane. Therefore, the departing passengers can effectively board the plane without having to wait for the arriving passengers to disembark the plane or for the crew to clean and restock the plane. The modular concept is also applicable to land vehicles such as a truck, automobile, HUMMVEE, or similar commercial or military vehicle, or to a space vehicle.

[38] Still referring to **FIGS. 1 – 4**, although the modular design of the ship ***100*** allows a crew to quickly and easily retrofit the ship for different types of missions, the hull design of the ship may limit the types of missions that the ship can execute, or may limit the performance of the ship when conducting mission.

[39] **FIGS. 5A** – **5D** are end views of a ship ***100*** of **FIG. 1** having a multi-mode hull ***510*** that allows the ship ***100*** to execute a mission with a suitable type of hull for that mission according to an embodiment of the invention. The multi-mode hull ***510*** is a foil-assisted twin hull that combines a plurality of functions from several proven hull designs. The multi-mode hull ***510*** allows the ship ***100*** to operate in at least the following four modes: a logistics mode (**FIG. 5A**), a catamaran mode (**FIG. 5B**), a SWATH mode (**FIG. 5C**), and a low freeboard mode (**FIG. 5D**). The crew can easily switch from one mode to another by merely adjusting the draft of the ship ***100***. The draft of the ship ***100*** can be adjusted by adjusting the water levels in the ballast tanks (not shown) or through movable buoyant devices (also not shown) using practices well-established in the maritime industry.

[40] Referring to **FIG. 5A**, in the logistics mode, the ship ***100*** rides higher in the water than it does in any other of the modes. A typical draft ***551*** for the hull ***510*** of a multi-mode hull ship ***100*** in the logistics mode is 9 feet. Therefore, in the logistics mode, the ship ***100*** is better suited to shallow-water tasks such as delivering a payload, such as module ***500,*** close to shore. Examples of other such tasks include close shore logistics support missions and ship-to-objective maneuvers (STOM). If adjusting the ballast of the ship ***100*** does not decrease the draft ***551*** sufficiently to put the hull in the logistics mode, the crew can secure to the ship ***100*** a buoyant module ***500*** that provides additional buoyancy sufficient to reduce the draft as needed.

[41] Referring to **FIG. 5B**, in catamaran mode, the ship ***100*** rides relatively high in the water such that the hull ***510*** acts as a catamaran hull. A typical draft 552 in catamaran mode is 12 feet. Therefore, in the catamaran mode, the hull ***510*** allows the ship ***100*** to travel at relatively high speeds in a relatively energy-efficient manner and in relatively shallow water, and to undertake tasks that require these abilities. Examples of such a task include search and rescue, surface-craft interdiction, high-speed pursuit of surface craft and submarines, and other missions requiring high speed.

[42] Referring to **FIG. 5C**, in SWATH mode, the ship ***100*** rides lower in the water than in the catamaran mode such that the hull ***510*** acts as a SWATH hull. In the SWATH mode, the ship ***100*** is slower and less energy efficient than in the catamaran mode, but it has better sea keeping and is better for transporting payloads or personnel long distances, and thus, is better for undertaking tasks that require these abilities. A typical draft ***553*** in SWATH mode is 20 feet.

[43] Referring to **FIG. 5D**, in low-freeboard mode, the ship ***100*** rides lower in the water than in the SWATH mode such that the ship ***100*** has a low-profile for stealth missions.

That is, the portion of the ship ***100*** that rides above the waterline in the low-freeboard mode is minimized to make the ship ***100*** less detectable than it is in the other three modes. Therefore, in the low-freeboard mode, the ship ***100*** is suited for undertaking tasks that require secrecy or that otherwise require the ship ***100*** to ride low in the water. Furthermore, any additional stealth features, such as the shapes of the above-water decks, need only be implemented on the portion of the ship ***100*** that rides above the waterline in the low-freeboard mode, and not on the other larger portions of the ship ***100*** that ride above the waterline in the other modes. A typical draft ***554*** in the low-freeboard mode is 32 feet.

[44] Other embodiments of the multi-mode hull ***510*** are contemplated. For example, the hull ***510*** may allow the ship ***100*** to operate in more or fewer than four modes, where some or all of these modes are different than those described above.

[45] Still referring to **FIGS. 5A – 5D**, the ship ***100*** may operate in one or more of the above-described hull modes when performing a single mission. For example, suppose the ship is to perform an anti-submarine-warfare mission at a location that is remote from the location where the crew loads the anti-submarine mission module ***105*** into the bay ***110***. At first, because the ship ***100*** (the frame ***115***, the module ***105***, or both) is loaded with fuel and supplies for the mission, the draft of the ship may be such that the ship operates in the SWATH mode (**FIG. 5C**). If the mission is secret, then the crew may add additional ballast (typically water) to cause the ship ***100*** to operate in the low-freeboard (stealth) mode (**FIG. 5D**). When the ship ***100*** reaches the mission location, then the fuel and supplies may be depleted sufficiently such that with the removal of a proper amount of ballast, the ship can operate in the catamaran mode (**FIG. 5B**) to, *e.g.*, chase a submarine.

[46] The preceding discussion is presented to enable a person skilled in the art to make and use the invention. The general principles described herein may be applied to embodiments and applications other than those detailed above without departing from the spirit and scope of the present invention. The present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed or suggested herein.